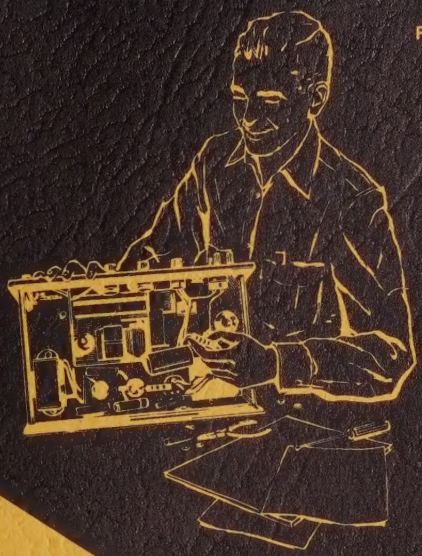
PRICE $1.00



CAL LAB
2-7360

Assembling

and Using Your...

Heathkit

HARMONIC DISTORTION METER

MODEL HD-1

ANALYZER

HEATH COMPANY

A Subsidiary of Daystrom Inc.

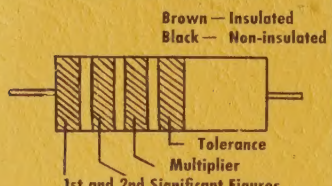
BENTON HARBOR, MICHIGAN

595-105

STANDARD COLOR CODE — RESISTORS AND CAPACITORS

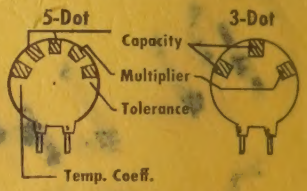
INSULATED UNINSULATED Color	FIRST RING BODY COLOR First Figure	SECOND RING END COLOR Second Figure	THIRD RING DOT COLOR Multiplier
BLACK	0	0	None
BROWN	1	1	0
RED	2	2	00
ORANGE	3	3	,000
YELLOW	4	4	0,000
GREEN	5	5	00,000
BLUE	6	6	000,000
VIOLET	7	7	0,000,000
GRAY	8	8	00,000,000
WHITE	9	9	000,000,000

AXIAL LEAD RESISTOR

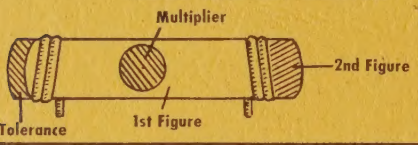


Wire wound resistors have 1st digit band double width

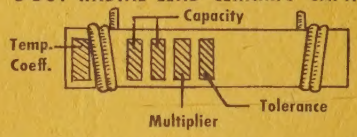
DISC CERAMIC RMA CODE



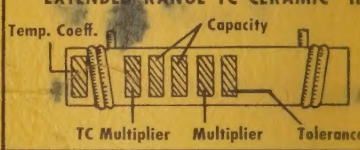
RADIAL LEAD DOT RESISTOR



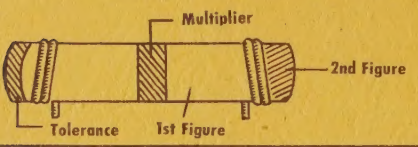
5-DOT RADIAL LEAD CERAMIC CAPACITOR



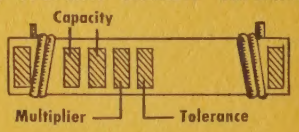
EXTENDED RANGE TC CERAMIC HICAP



RADIAL LEAD (BAND) RESISTOR



BY-PASS COUPLING CERAMIC CAPACITOR



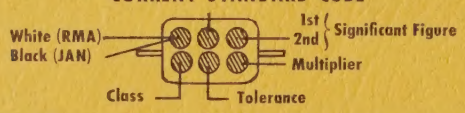
AXIAL LEAD CERAMIC CAPACITOR

The standard color code provides all necessary information required to properly identify color coded resistors and capacitors. Refer to the color code for numerical values and the zeroes or multipliers assigned to the colors used. A fourth color band on resistors determines tolerance rating as follows: Gold = 5%, silver = 10%. Absence of the fourth band indicates a 20% tolerance rating.

The physical size of carbon resistors is determined by their wattage rating. Carbon resistors most commonly used in Heathkits are ½ watt. Higher wattage rated resistors when specified are progressively larger in physical size. Small wire wound resistors ½ watt, 1 or 2 watt may be color coded but the first band will be double width.

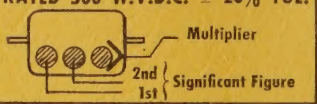
MOLDED MICA TYPE CAPACITORS

CURRENT STANDARD CODE

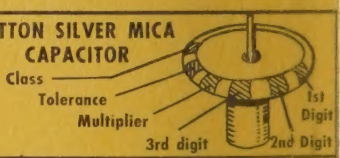


JAN & 1948 RMA CODE

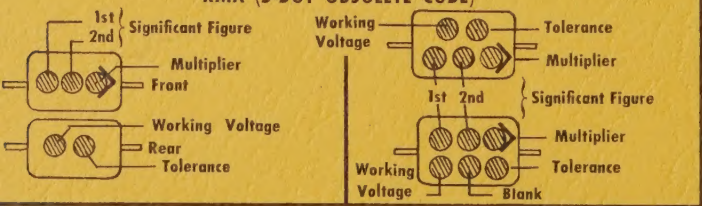
RMA 3-DOT (OBSOLETE) RATED 500 W.V.D.C. ± 20% TOL.



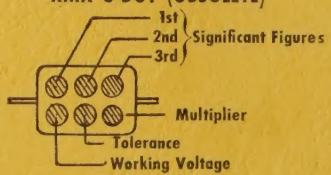
BUTTON SILVER MICA CAPACITOR



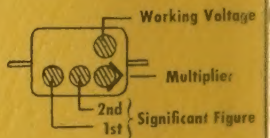
RMA (5-DOT OBSOLETE CODE)



RMA 6-DOT (OBSOLETE)

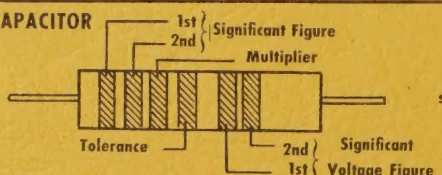


RMA 4-DOT (OBSOLETE)



MOLDED PAPER TYPE CAPACITORS

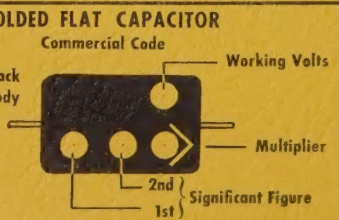
TUBULAR CAPACITOR



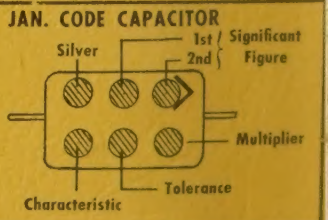
Normally stamped for value

A 2 digit voltage rating indicates more than 900 V. Add 2 zeros to end of 2 digit number.

MOLDED FLAT CAPACITOR



JAN. CODE CAPACITOR

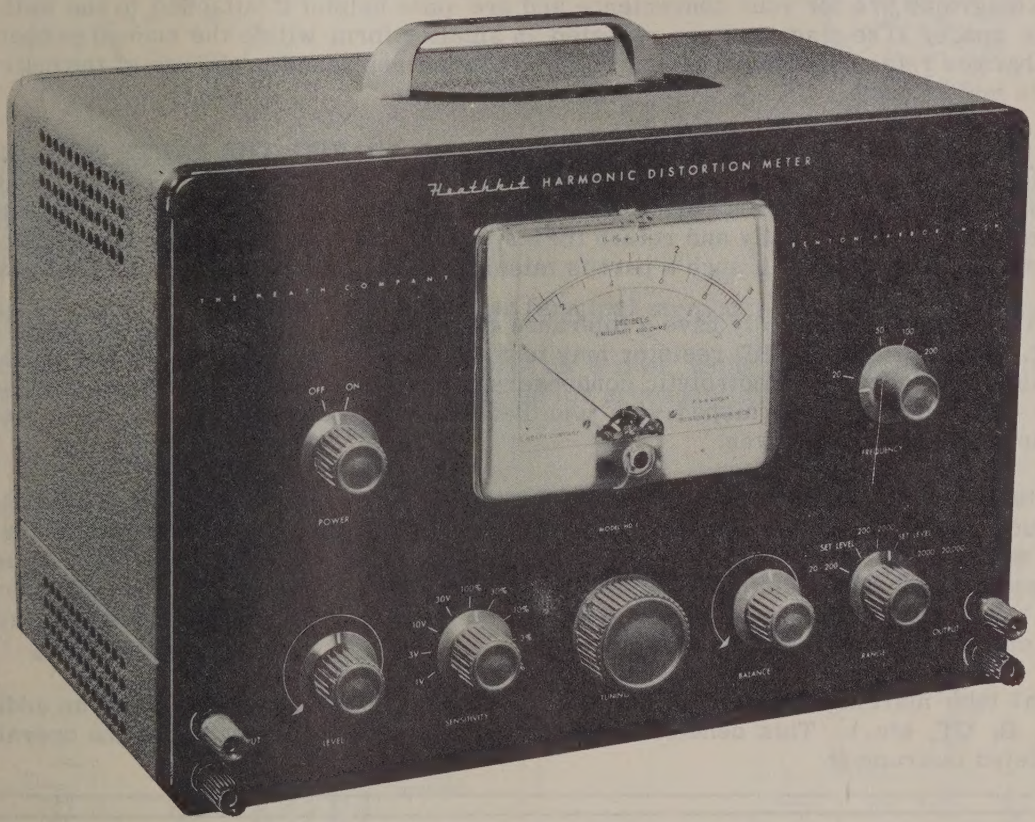


The tolerance rating of capacitors is determined by the color code. For example: red = 2%, green = 5%, etc. The voltage rating of capacitors is obtained by multiplying the color value by 100. For example: orange = 3 × 100 or 300 volts. Blue = 6 × 100 or 600 volts.

In the design of Heathkits, the temperature coefficient of ceramic or mica capacitors is not generally a critical factor and therefore Heathkit manuals avoid reference to temperature coefficient specifications.

Courtesy of Centralab

HEATHKIT
HARMONIC DISTORTION METER
MODEL HD-1



SPECIFICATIONS

Frequency	20 cycles to 20,000 cycles in three ranges
Distortion	0-1, -3, -10, -30, -100% full scale
Voltmeter	0 - 1 - 3 - 10 - 30 volts full scale
Input Resistance	300 KΩ
Minimum Input Voltage for Distortion Measurement	0.3 volts
Output Voltage for Monitoring	2.5 volts at full scale meter reading
Accuracy:	
Voltmeter	±5% of full scale
Distortion	±5% of full scale, +0.1%
Tube Complement	OA2, 6X4, 5879, 12AT7, 12AX7, 12BY7
Power Requirements	105-125 volts 50/60 cycles, 30 watts
Dimensions	13" wide x 8 1/2" high x 7" deep
Net Weight	11 lbs.
Shipping Weight	13 lbs.

INTRODUCTION

This Heathkit is the result of many years of engineering effort to reduce the costly and complex devices heretofore used for harmonic distortion measurements to the simple and easy-to-construct level so traditional in Heathkits, without sacrificing the necessary accuracy, stability and operating convenience.

The detailed instructions in this manual were specifically written with your problems in mind. We suggest that you take a few minutes now, before starting any construction and read the entire manual. In this way, you will obtain a rough idea of the assembly process. The large fold-in pictorial diagrams are for your convenience and are quite helpful if attached to the wall above your work space. The diagrams are repeated in smaller form within the manual proper. We suggest that you retain the manual in your files for future reference in the use of the instrument and for its maintenance.

UNPACK THE KIT CAREFULLY. CHECK EACH PART AGAINST THE PARTS LIST. Use the information on the inside covers of this manual to identify small parts. DO NOT DISCARD any packing materials before all parts are accounted for. If after a thorough search a shortage is found, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight. If such a part is missing, please obtain it locally if at all possible.

Resistors and controls generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Therefore, a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ and still be acceptable. Tolerances on electrolytic condensers may be even wider and commonly run from +100% to -50%. The parts furnished with your Heathkit have been specified so as to meet the performance specifications given.

In order to expedite delivery to you, we are occasionally forced to make minor substitutions of parts. Such substitutions are very carefully checked before they are approved and the parts supplied will work satisfactorily in your kit. For example, if your kit is short a 2.2 megohm resistor and a 2 megohm resistor is furnished which is not on the parts list, you will understand that such a substitution has been made. This fact is mentioned here only to prevent any confusion in checking the contents of the kit.

The actual tube markings may differ from the type specified in the parts list by an additional suffix (A, B, GT, etc.). This denotes a minor variation which will not affect the operation of the completed instrument.

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

STEP-BY-STEP ASSEMBLY

1. Read each step through before starting on it.
2. Check each step off ( ) when completed.
3. Attach the appropriate pictorial to the wall above your work space.
4. Lay the parts out in a large shallow box so that they are easy to get at.
5. Use insulated wire unless another type is specified.

(S) means solder this connection. (NS) means do not solder connection yet.

MOUNTING THE PARTS

( ) Install the tube sockets (three 9-pin wafer, two 7-pin wafer, one 9-pin shielded) as shown with the blank spaces oriented as in Pictorial 1. Use 3-48 screws and nuts. The wafer sockets mount below the chassis. The shielded socket mounts from the top of the chassis.

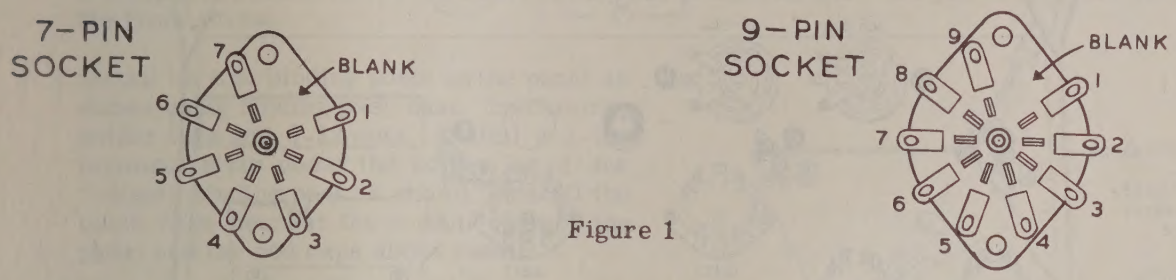


Figure 1

( ) Install the condenser mounting wafer above the chassis with 6-32 screws and nuts. Use #6 lockwashers under the nuts. Include a 2-lug + 1 grounded lug terminal strip between chassis and lockwasher as shown.
( ) Install three rubber grommets as shown.

( ) Install two 1-lug, one 2-lug and one 3-lug terminal strip as shown, with 6-32 screws, nuts and lockwashers.
( ) Install a 100 Ω control and a 500 Ω control as shown, using fiber washers, control lockwashers and control nuts. Bend the lugs up for accessability.

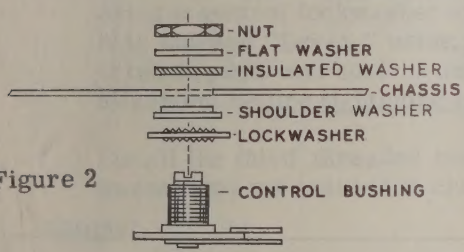


Figure 2

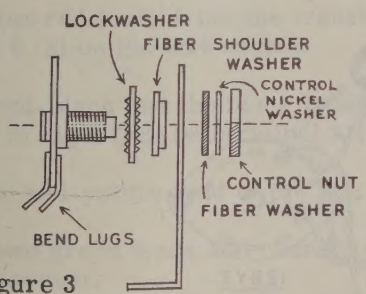


Figure 3

( ) Install the other 100 Ω control in the same manner on the control bracket.
( ) Install the control bracket on the chassis with 6-32 hardware. Make sure this control is properly lined up with the hole in the back of the chassis.

( ) Install the power transformer. Use 8-32 nuts and lockwashers.
( ) Install the tuning condenser insulator plate on top of the chassis together with the upper and lower front shields and the rear shields. Use 6-32 hardware. Note the position of the insulator plate.

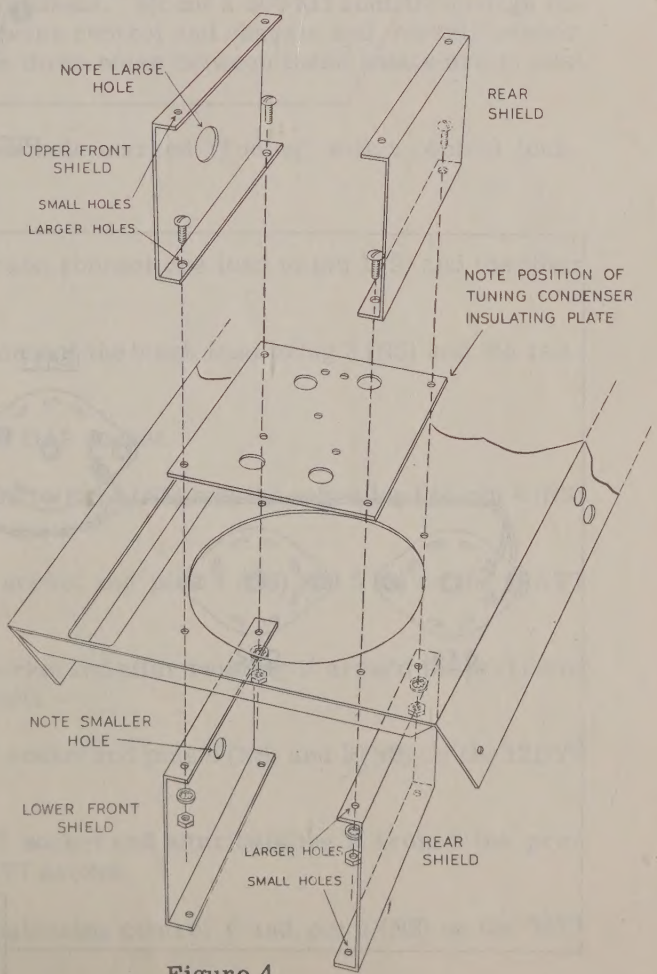
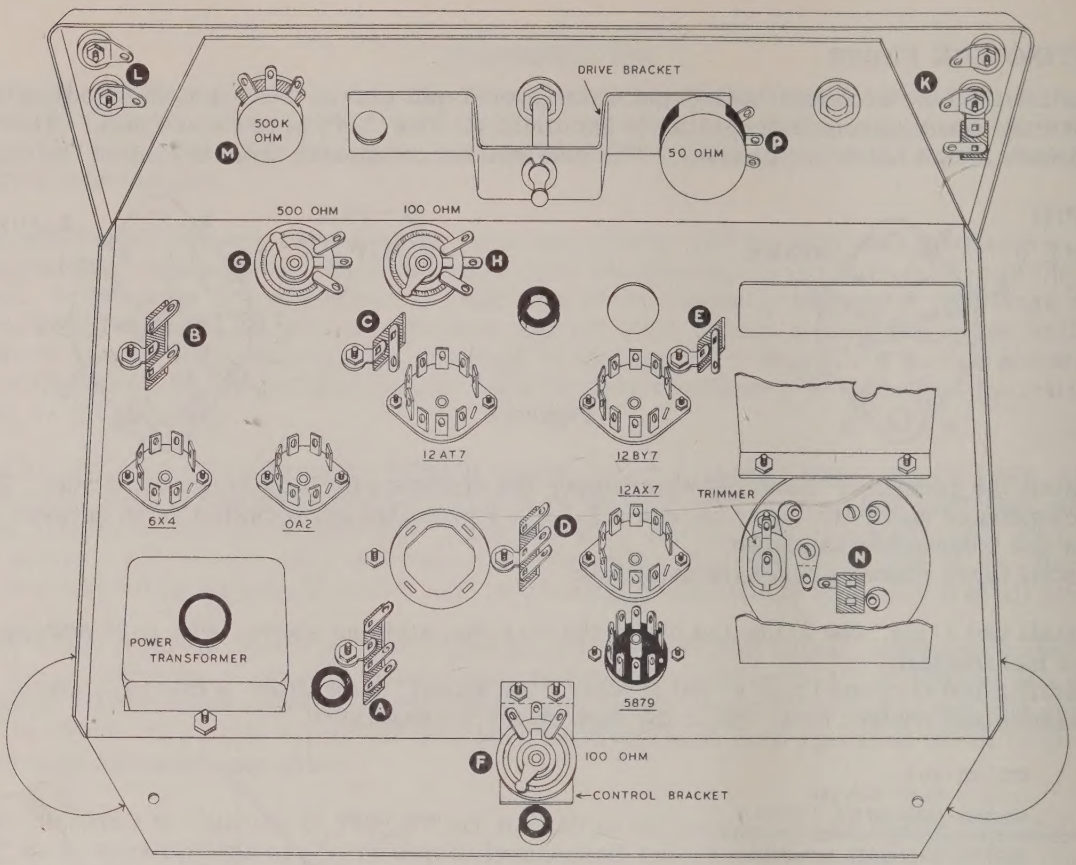


Figure 4



PICTORIAL 1

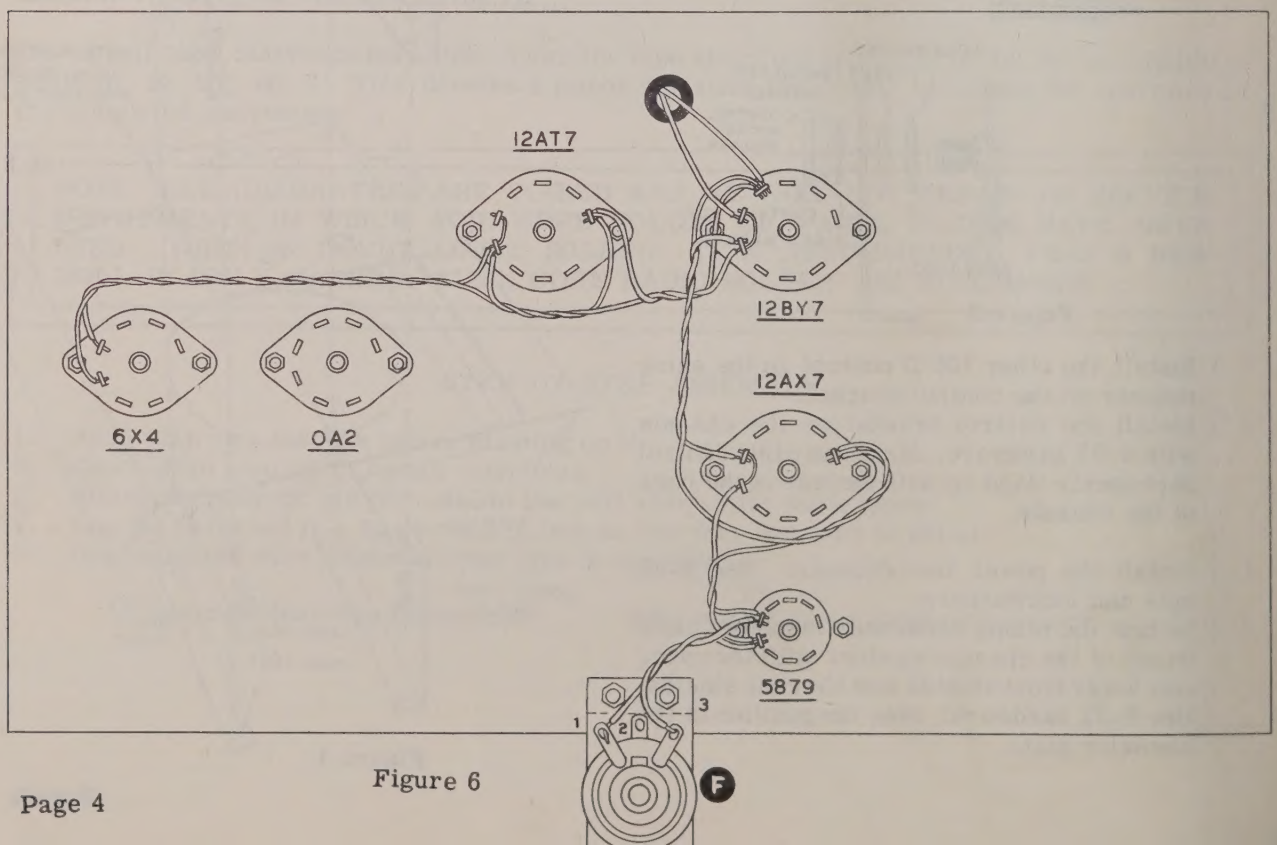


Figure 6

( ) Install the 5-20 $\mu\mu$f trimmer condenser as shown with 6-32 hardware.

( ) Install the tuning condenser on top of the insulator plate using three short 6-32 screws. Install a solder lug under the screw nearest the trimmer. Install a 1-lug terminal strip with a lockwasher under the screw nearest the rear of the chassis. Use just a lockwasher under the front screw.

( ) Install the four binding posts on the panel as shown using binding post base, insulators, solder lugs and 6-32 nuts. Install a 1-lug terminal strip under the solder lug of one "output" binding post as shown. Install the black caps nearest the bottom edge of the panel and the red caps above them.

( ) Install the rotary off-on switch on the panel in the hole marked "Power" with a control lockwasher between switch and panel and a nickel washer between panel and control nut.

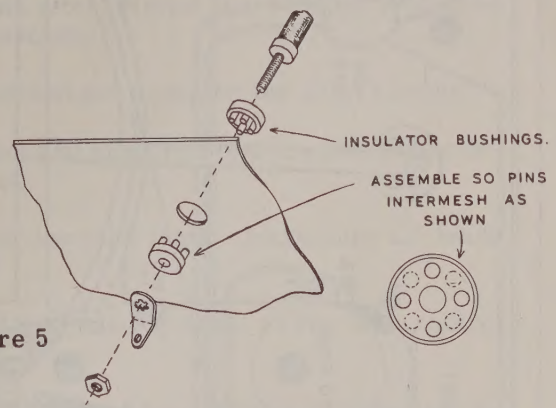


Figure 5

( ) Install a threaded bushing on the panel in the hole marked "Frequency." Use a control lockwasher and nut behind the panel.

( ) Attach the panel to the chassis with a threaded bushing through the hole marked "Range," using a control lockwasher and nut inside the chassis. Mount a 500 KΩ control through the hole marked "Level," using a lockwasher between control and chassis and nickel washer between panel and control nut. Make sure the three holes between these points are in best alignment before tightening the nuts.

( ) Install the third threaded bushing in the center hole marked "Tuning" with a control lockwasher and nut inside the chassis.

WIRING

( ) Twist the two red leads from the transformer and connect one lead to pin 1 (S) and the other lead to pin 6 (S) on the 6X4 socket.

( ) Twist the red-black and the black leads and connect the black lead to lug 3 (NS) and the red-black lead to lug 1 (NS) on terminal strip A.

( ) Connect the red-yellow lead to pin 2 (S) on the OA2 socket.

( ) Twist the two green leads and connect one lead to pin 3 (NS) and the other lead to pin 4 (NS) on the 6X4 socket.

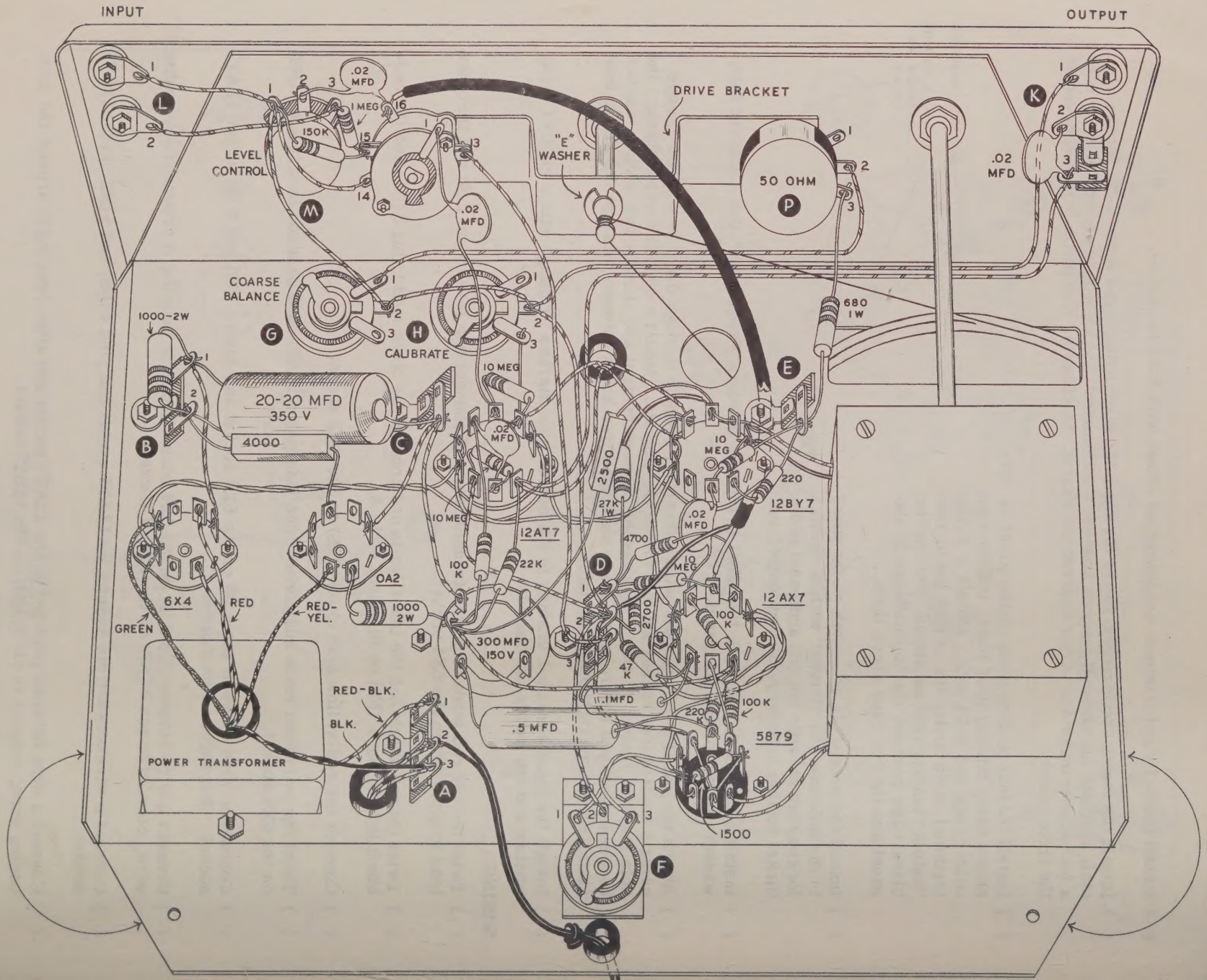
( ) Connect a wire between pin 4 (S) on the 6X4 socket and pins 4 (NS) and 5 (S) on the 12AT7 socket. See Figure 6 on Page 4.

( ) Connect a wire between pin 3 (S) on the 6X4 socket and after twisting it around the preceding wire, connect to pin 9 (NS) on the 12AT7 socket.

( ) Connect a wire between pin 4 (S) on the 12AT7 socket and pins 4 (NS) and 5 (NS) on the 12BY7 socket.

( ) Connect a wire between pin 9 (S) on the 12AT7 socket and after twisting it around the preceding wire, connect to pin 6 (NS) on the 12BY7 socket.

( ) Connect a wire between lug 1 (S) on the hum balancing control F and pin 5 (NS) on the 5879 socket.


INPUT
OUTPUT
DRIVE BRACKET
LEVEL CONTROL
150K
1 MEG
.02 MFD
"E" WASHER
50 OHM
COARSE BALANCE
CALIBRATE
1000-2W
20-20 MFD 350 V
4000
10 MEG
2500
27K 1W
680 1W
220
12BY7
12AT7
100 K
22K
4700
12 AX7
0A2
6X4
RED
GREEN
RED-YEL.
1000 2W
300 MFD 150V
2700
47 K
.1MFD
.5 MFD
100K
220 K
5879
1500
RED-BLK.
BLK.
POWER TRANSFORMER
A
B
C
D
E
F
G
H
K
L
M
P

( ) Connect a wire between lug 3 (S) on the hum balancing control F and after twisting it around the preceding wire, connect to pin 4 (NS) on the 5879 socket.

( ) Connect a wire between pin 4 (S) on the 5879 socket and pin 9 (NS) on the 12AX7 socket.

( ) Connect a wire between pin 5 (S) on the 5879 socket and after twisting it around the preceding wire, connect to pins 4 (S) and 5 (NS) on the 12AX7 socket.

( ) Connect a wire between pin 9 (S) on the 12AX7 socket and pin 6 (NS) on the 12BY7 socket.

( ) Connect a wire between pin 5 (S) on the 12AX7 socket and after twisting it around the preceding wire, connect to pin 4 (S) on the 12BY7 socket.

This completes the wiring of the heater circuit except for the pilot lamp. Make sure all leads are dressed as shown in the pictorial.

( ) Connect a wire between the "hot" input binding post L2 (S) and lug 3 (NS) on the level control M.

( ) Connect a wire between the "cold" input binding post L1 (S) and lug 1 (NS) on level control M.

( ) Connect a wire between lug 1 (NS) on control M and lug 2 (NS) on coarse balance control G.

( ) Connect a wire between lug 2 (S) on control G and lug 2 (NS) on the voltmeter calibration control H.

( ) Connect a wire between the "cold" output terminal K1 (S) and lug 2 (NS) on control H.

( ) Connect a wire between lug 2 (S) on control H and lug 2 (NS) on terminal strip D.

( ) Connect a wire between pin 7 (S) on the OA2 socket and the lug (NS) on terminal strip C.

( ) Connect a wire between the lug (NS) on terminal strip N on the tuning condenser insulating plate and pin 2 (NS) on the 5879 socket.

( ) Connect a bare wire between pin 2 (NS) and pin 6 (NS) on the 5879 socket. Lay this wire against the center shield (S).

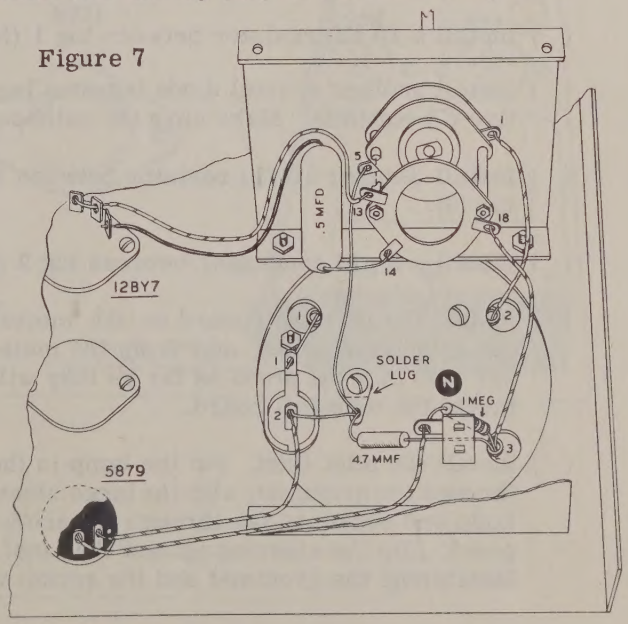
( ) Connect a bare wire between pin 2 (S) and pin 9 (NS) on the 5879 socket.

( ) Connect a wire between pin 6 (S) on the 5879 socket and lug 2 (NS) on terminal strip D.

( ) Connect a wire between lug 2 (S) on hum balancing control F and lug 2 (NS) on terminal strip D.

( ) Connect a wire between pin 3 (NS) on 12AT7 socket and lug 2 (NS) on terminal strip D.

Figure 7



( ) Connect a bare wire between lug 1 (S) on the tuning condenser and lug 1 (S) on the trimmer condenser.

( ) Connect a wire between pin 1 (S) on the 5879 socket and lug 2 (NS) on the trimmer condenser. Place this wire along an earlier wire, as far as the rear shield.

( ) Connect a bare wire between lug 2 (S) on the trimmer condenser and the solder lug (NS).

( ) Install a 4.7 $\mu\mu$f condenser between the solder lug (NS) and lug 3 (NS) on tuning condenser.

( ) Install a 1 megohm resistor between the lug (S) on terminal strip N and lug 3 (NS) on the tuning condenser.

( ) Connect a bare wire between pin 8 (NS) on the 12AT7 socket and lug 3 (S) on control H.

( ) Install a .02 μfd condenser between lug K2 (S) and lug K3 (NS).

( ) Connect a wire between lug K3 (S) and pin 1 (NS) on the 12AT7 socket.

( ) Connect a wire between pin 7 (S) on the 6X4 socket and lug 1 (NS) on terminal strip B.

( ) Install a 20-20 μfd 350 volt condenser between terminal strips B and C with the single lead to the lug (NS) on strip C and the other two leads to lugs 1 (NS) and 2 (NS) on strip B.

( ) Install a 1000 Ω 2 watt resistor between lug 1 (S) and lug 2 (NS) on terminal strip B.

( ) Install a 4000 Ω 7 watt resistor between lug 2 (S) on strip B and pin 5 (S) on the OA2 socket.

( ) Install a 1500 Ω resistor between pin 9 (S) and pin 3 (S) on the 5879 socket.

( ) Install the meter on the panel with the hardware provided.

( ) On the meter terminal board, install the large rubber grommet.

( ) Install a crystal diode between lug 2 (NS) and the large positive (+) lug (NS). Make sure the cathode is connected to the positive lug. The cathode may be indicated by various markings such as a dot or a line, an arrow point, a + sign, the letter K or a brown ring.

( ) Install a 10 KΩ resistor between lug 1 (NS) and the positive lug (S).

( ) Install another crystal diode between lug 2 (NS) and the large negative (-) lug (NS). Make sure the cathode is connected to lug 2.

( ) Install another 10 KΩ resistor between lug 1 (NS) and the negative lug (S).

( ) Install a 2 μfd condenser between lug 2 (S) and lug 3 (NS).

( ) Install the terminal board on the meter studs after removing the outer nuts and solder lugs from the meter studs and running the inner nuts onto the studs as far as they will go. Use the outer nuts to mount the terminal board.

( ) Install the pilot light. Put the lamp in the socket and push the lamp through the grommet; slip the large sleeving over the lamp and push lamp and socket as far through the grommet as it will go toward the panel. Slip the sleeving against the panel so it acts as a light shield. Moistening the grommet and the socket will facilitate installation.

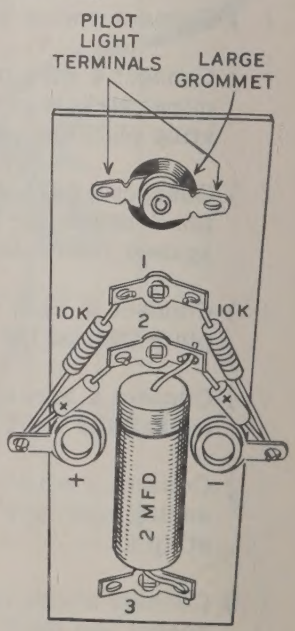
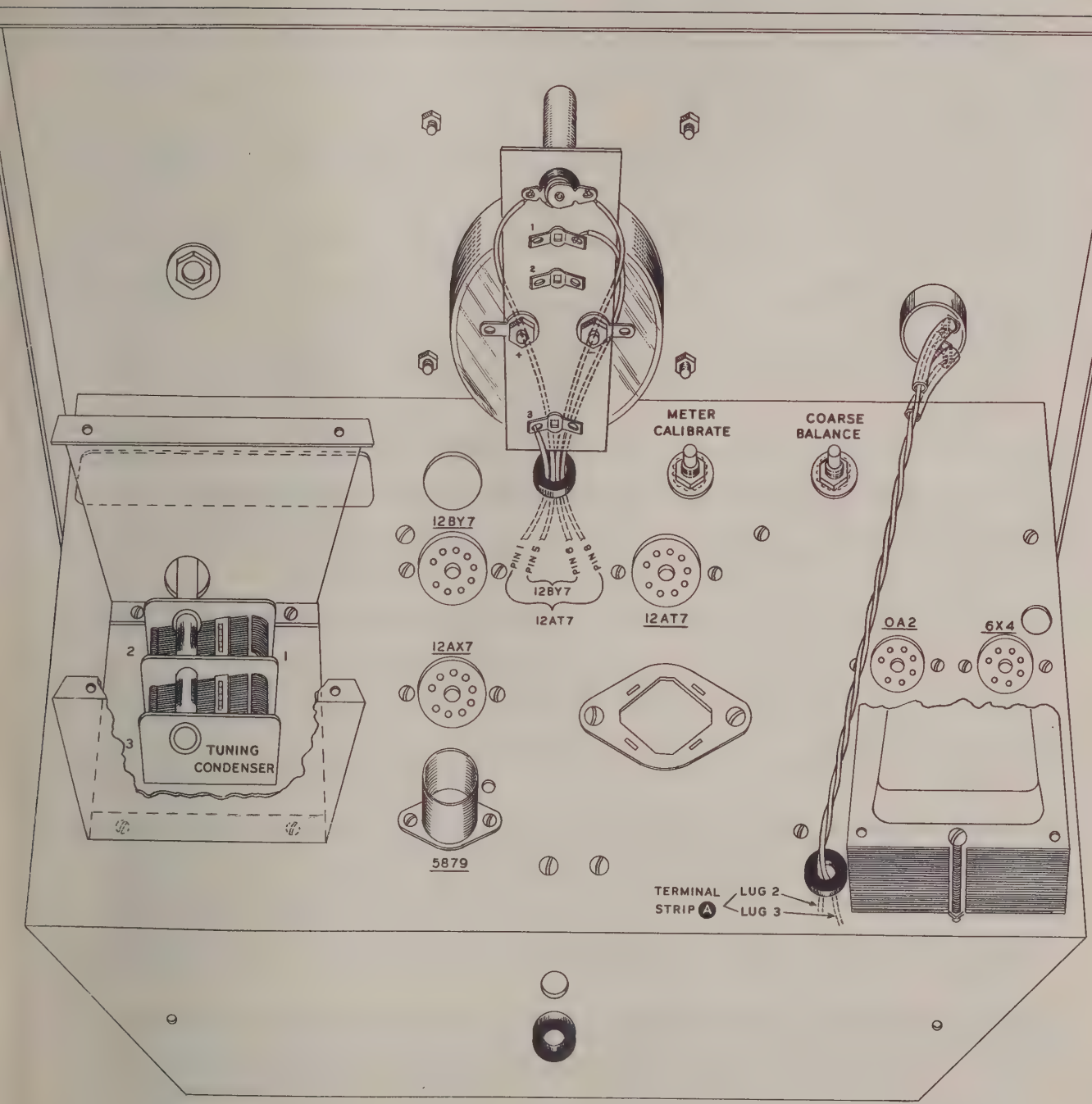


Figure 8

( ) Connect a wire between one pilot light terminal (S) and pin 5 (S) on the 12BY7 socket.

( ) Connect a wire between the other pilot light terminal (S) and pin 6 (S) on the 12BY7 socket.

( ) Connect a wire between lug 3 (S) on the terminal board and pin 1 (NS) on the 12AT7 socket.


METER CALIBRATE
COARSE BALANCE
12BY7
PIN 1
PIN 5
PIN 9
12BY7
12AT7
12AT7
12AX7
5879
0A2
6X4
TUNING CONDENSER
TERMINAL STRIP A
LUG 2
LUG 3

PICTORIAL 3

( ) Connect a wire between lug 1 (S) on the terminal board and pin 8 (NS) on the 12AT7 socket.

Make sure all connections on the meter terminal board are properly soldered.

( ) Install the 300 μfd 150 volt filter condenser by passing the four mounting prongs through the slots in the mounting wafer on the chassis. Make sure the condenser is properly positioned, then twist each mounting prong 1/8 turn with pliers.

( ) Connect a wire between the lug (S) on terminal strip C and the nearest twisted mounting prong (S) on the filter condenser.

( ) Install a .5 μfd condenser between another twisted ground lug (S) on the filter condenser and pin 7 (NS) on the 5879 socket.

( ) Connect a wire between the terminal lug (NS) on the filter condenser and pin 1 (NS) on the 12AX7 socket.

( ) Install a 220 KΩ resistor between pin 1 (NS) on the 12AX7 socket and pin 7 (S) on the 5879 socket.

( ) Install a 100 KΩ resistor between pin 1 (NS) on the 12AX7 socket and pin 8 (NS) on the 5879 socket.

( ) Connect a bare wire between pin 8 (S) on the 5879 socket and pin 2 (S) on the 12AX7 socket.

( ) Install a 100 KΩ resistor between pin 1 (S) and pin 6 (NS) on the 12AX7 socket.

( ) Install a .1 μfd condenser between pin 3 (NS) on the 12AX7 socket and lug 3 (NS) on terminal strip D.

( ) Install a 47 KΩ resistor between pin 3 (S) on the 12AX7 socket and lug 1 (NS) on terminal strip D.

( ) Install a .02 μfd disc condenser between pin 6 (S) on the 12AX7 socket and pin 2 (NS) on the 12BY7 socket.

( ) Install a 4700 Ω resistor between pin 8 (S) on the 12AX7 socket and lug 1 (NS) on terminal strip D.

( ) Install a 27 KΩ 1 watt resistor between pin 7 (NS) on the 12BY7 socket and lug 1 (NS) on terminal strip D. Use sleeving between pin 7 and the resistor.

( ) Install a 2700 Ω resistor between lug 1 (NS) and lug 2 (NS) on terminal strip D.

( ) Install a 10 megohm resistor between pin 7 (NS) on the 12AX7 socket and lug 1 (S) on terminal strip D.

( ) Install a 10 megohm resistor between pin 8 (S) and pin 7 (NS) on the 12AT7 socket.

( ) Install another 10 megohm resistor between pin 3 (S) and pin 2 (NS) on the 12AT7 socket.

( ) Install a .02 μfd disc condenser between pin 2 (S) and pin 6 (NS) on the 12AT7 socket.

( ) Install a 100 KΩ resistor between pin 6 (S) on the 12AT7 socket and the terminal lug (NS) on the filter condenser.

( ) Install a 22 KΩ resistor between pin 1 (S) on the 12AT7 socket and the terminal lug (NS) on the filter condenser.

( ) Install a 1000 Ω 2 watt resistor between pin 1 (S) on the OA2 socket and the terminal lug (NS) on the filter condenser.

PRE-WIRING THE SENSITIVITY SWITCH

( ) Connect a bare wire through lug 12 (S), lug 2 (S) and lug 11 (NS). Use sleeving between lugs 2 and 11.

( ) Install a 683.8 KΩ precision resistor between lug 11 (NS) and lug 3 (NS).

( ) Connect a bare wire between lug 3 (S) and lug 10 (NS). Use sleeving.

( ) Install a 216.2 KΩ precision resistor between lug 10 (NS) and lug 4 (NS).

( ) Connect a bare wire between lug 4 (S) and lug 9 (NS). Use sleeving.

( ) Install a 68.38 KΩ precision resistor between lug 9 (NS) and lug 5 (NS).

( ) Connect a bare wire between lug 5 (S) and lug 8 (NS). Use sleeving.

( ) Install a 21.62 KΩ precision resistor between lug 8 (NS) and lugs 6 (S) and 7 (NS).

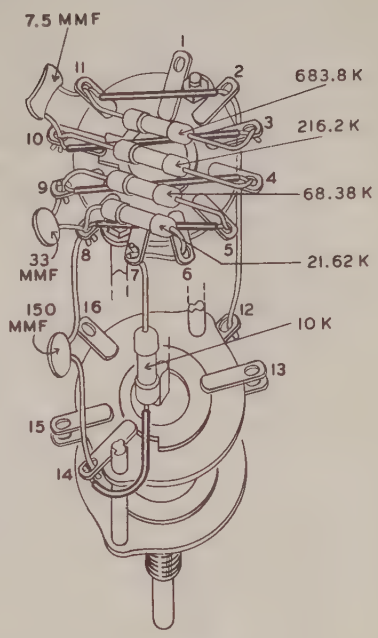


Figure 9

( ) Install a 10 KΩ precision resistor between lug 7 (S) and lug 14 (NS).

( ) Install a 7.5 μμf mica condenser between lug 11 (S) and lug 10 (S).

( ) Install a 33 μμf disc condenser between lug 9 (S) and lug 8 (NS).

( ) Install a 150 μμf disc condenser between lug 8 (S) and lug 14 (NS).

This completes the pre-wiring of the sensitivity switch. Make sure no part of the wiring touches the shaft, the rotor or the contact clips.

( ) Mount the drive bracket. Install the 50 Ω control in the panel hole marked BALANCE. Use a control lockwasher between the control and the drive bracket and a nickel washer between the panel and the control nut. Line up the other large hole in the drive bracket with the panel hole marked SENSITIVITY.

( ) Connect a wire between lug 2 (S) on the balance control P and lug 1 (S) on the coarse balance control G.

( ) Install the sensitivity switch in the proper panel hole with a control lockwasher between the switch and the drive bracket and a nickel washer between the panel and the control nut. Position the switch with lugs 13 and 15 (the double lugs) parallel to the edge of the panel and lug 15 toward the input level control.

( ) Install the drive shaft with two "E" washers, one on each side of the drive bracket. If necessary, adjust the drive bracket so that the shaft turns freely.

( ) Install the insulated coupling on the tuning condenser shaft. Install the extension shaft through the panel bushing and through the large drive pulley into the insulated coupling. Use two short 8-32 x 1/8 set screws in the coupling and a slightly longer 8-32 x 3/16 set screw in the drive pulley hub. NOTE: If necessary, loosen the three tuning condenser mounting screws and the nut on the panel bushing temporarily, so the shaft turns freely.

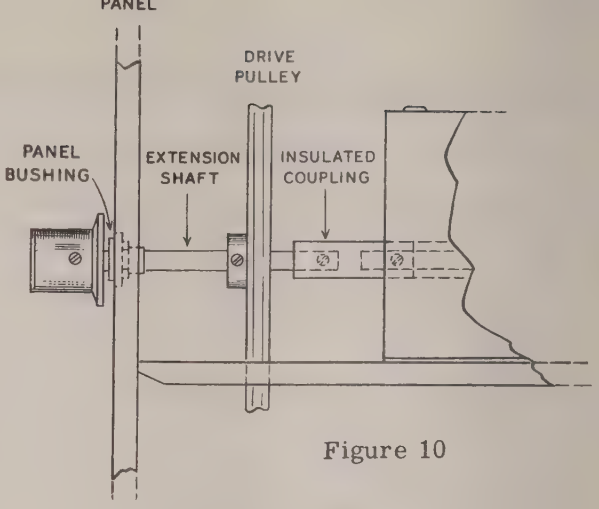


Figure 10

( ) Install the dial cord as shown in Figure 11. It may be convenient to attach the dial cord to the spring; then attach the spring to the drive pulley. Now place the cord as shown but go only once around the drive shaft. Hook the eyelet on the other end of the dial cord to the drive pulley. Then put the additional two turns around the drive shaft.

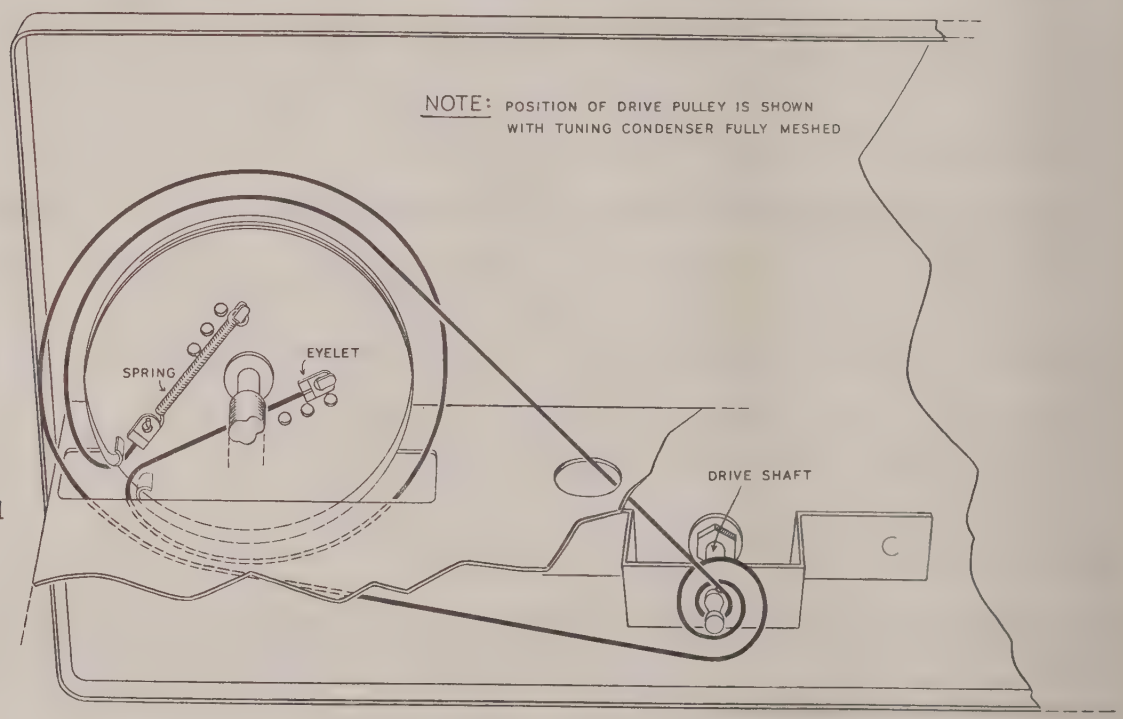


Figure 11

( ) Install a 680 Ω 1 watt resistor between lug 3 (S) on the balance control P and the lug (NS) on terminal strip E. Make sure this resistor does not interfere with the operation of the dial cord.

PRE-WIRING THE RANGE SWITCH

( ) Install a 20 megohm precision resistor between lug 2 (S) and lugs 11 (S) and 12 (NS).

( ) Install a 2 megohm precisions resistor between lug 3 (S) and lug 12 (NS).

( ) Install a 200 KΩ precision resistor between lug 4 (S) and lugs 13 (NS) and 12 (S).

( ) Install a 20 megohm precision resistor between lug 6 (S) and lugs 14 (NS) and 15 (NS).

( ) Connect a bare wire between lug 7 (S) and lugs 15 (S) and 16 (NS).

( ) Install a 2 megohm precision resistor between lug 8 (S) and lugs 16 (S) and 17 (NS).

( ) Connect a bare wire between lug 9 (S) and lugs 17 (S) and 18 (NS).

( ) Install a 200 KΩ precision resistor between lug 10 (S) and lug 18 (NS).

This completes the pre-wiring of the range switch.

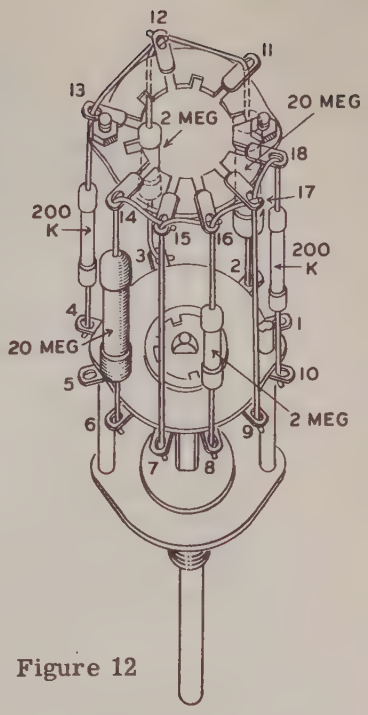


Figure 12

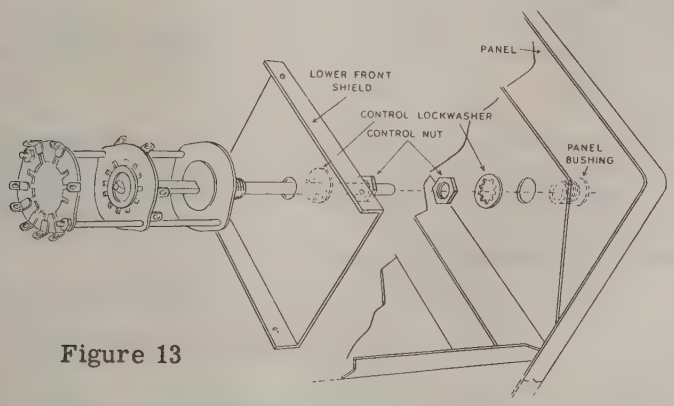


Figure 13

( ) Install the range switch through the lower front shield, a control lockwasher, a control nut and the panel bushing. See Figure 13.

( ) Connect a wire between lug 1 (S) on the switch and lug 2 (S) on the tuning condenser.

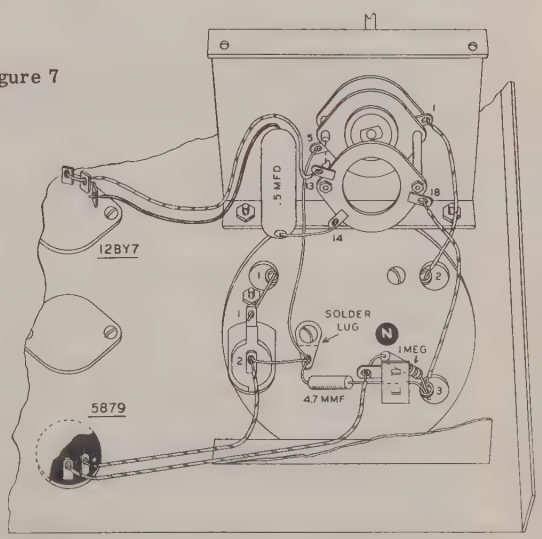
( ) Connect a wire between lug 18 (S) on the switch and lug 3 (S) on the tuning condenser.

( ) Connect a bare wire between lug 5 (S) on the switch and the solder lug (S) on the tuning condenser insulating plate.

( ) Install a .5 μfd condenser between lug 14 (S) on the switch and pin 9 (NS) on the 12BY7 socket. Use sleeving over this last lead. Dress lead along the front shield as shown.

( ) Connect a wire between lug 13 (S) on the switch and through pin 8 (S) to pin 7 (NS) on the 12BY7 socket. Dress this wire along the front shield as shown.

Figure 7



This completes the wiring of the range switch section.

( ) Install a 220 Ω resistor between the lug (NS) on terminal strip E and through pin 1 (S) to pin 9 (S) on the 12BY7 socket.

( ) Install a 10 megohm resistor between the lug (S) on terminal strip E and pin 2 (S) on the 12BY7 socket.

( ) Connect a wire between lug 3 (S) on terminal strip D and lug 13 (S) (double lug) on the sensitivity switch.

( ) Connect a wire between lug 14 (S) on the sensitivity switch and lug 1 (NS) on the level control.

( ) Install a 150 KΩ resistor between lug 1 (S) on the level control and lug 15 (NS) (double lug) on the sensitivity switch.

( ) Install a 1 megohm resistor between lug 15 (S) on the sensitivity switch and lug 3 (S) on the level control.

( ) Install a .02 μfd disc condenser between lug 2 (S) on the level control and lug 16 (NS) on the sensitivity switch. (This dummy lug is used only for a tie point.)

( ) Install another .02 μfd disc condenser between lug 1 (S) on the sensitivity switch and pin 7 (S) on the 12AT7 socket.

( ) Install a 2500 Ω 5 watt resistor between the terminal lug (S) on the filter condenser and pin 7 (S) on the 12BY7 socket. Do not cut the leads on this resistor but use the leads to raise the resistor body away from the chassis.

( ) Prepare the ends of the shielded wire as shown in Figure 14.

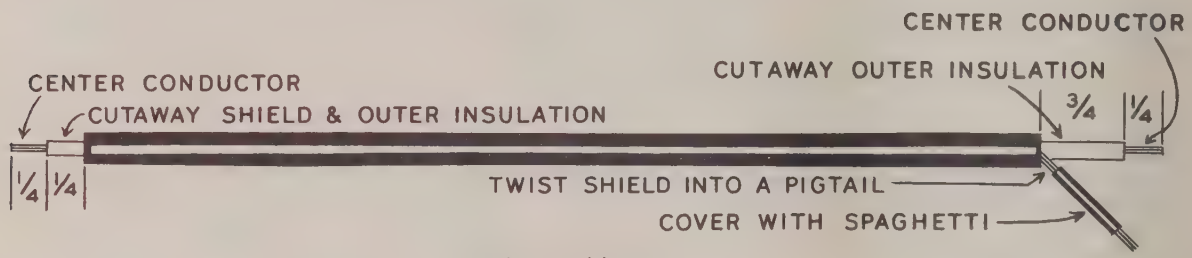


Figure 14

( ) Install the shielded wire with the pigtail to lug 2 (S) on terminal strip D, the adjacent center conductor to pin 7 (S) on the 12AX7 socket and the center conductor of the other end to lug 16 (S) on the sensitivity switch.

( ) Connect a wire between lug 2 (NS) on terminal strip A and one lug (S) on the power switch. Use a short piece of large sleeving over the switch lug. See Pictorial 3.

( ) Connect a wire between lug 3 (S) on terminal strip A and the other lug (S) on the power switch. Use sleeving.

( ) Insert the line cord through the grommet in the rear of the chassis. Tie a knot for strain relief and connect one lead to lug 1 (S) and the other lead to lug 2 (S) on terminal strip A.

This completes the wiring portion of the instrument. Carefully inspect all of the wiring. Shake out loose bits of wire trimmings and solder splashes. Double check all solder connections.

( ) Install the bottom shield over the range switch and the top shield over the tuning condenser with #6 sheet metal screws.

( ) Install the tubes in their proper sockets. Refer to Figure 15 on Page 15 for this.

( ) Install the large knob on the tuning shaft with an 8-32 x 1/4 set screw.

( ) Install the indicator (smooth knob) with an 8-32 x 3/16 set screw, on the frequency shaft.

( ) Install the other five knobs with 8-32 x 1/4 set screws.

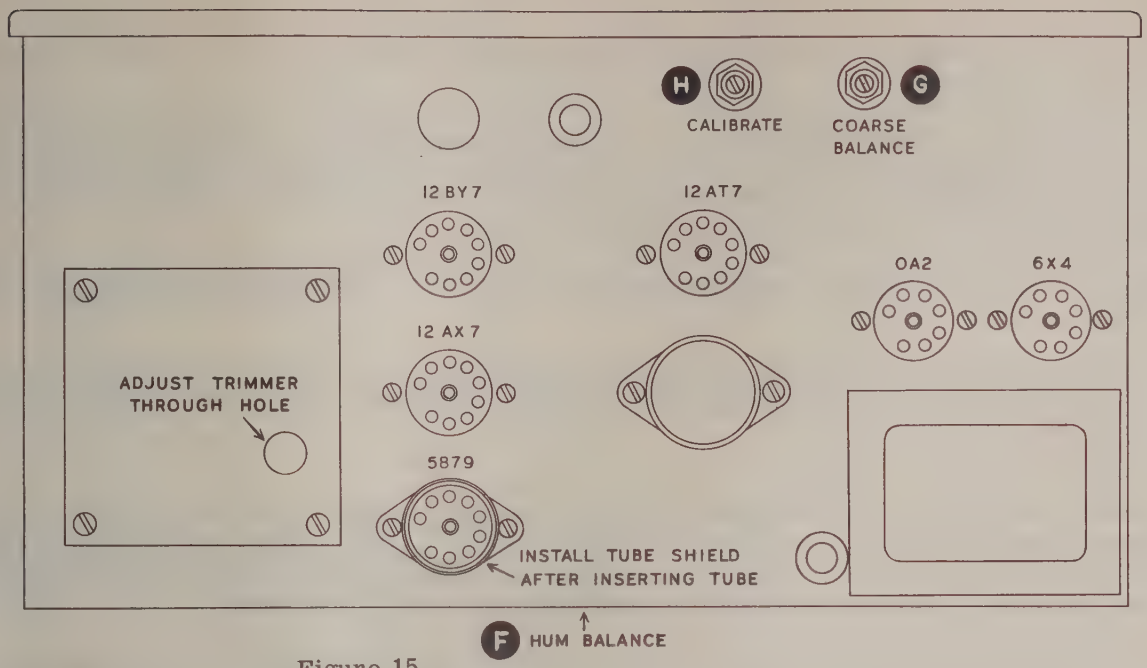
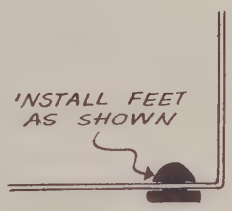


Figure 15

( ) Prepare the cabinet: Install the rubber feet by pushing them into the four holes in the bottom (moistening the rubber makes this easier).

( ) Mount the handle on top of the cabinet with 10-24 screws.



TEST AND CALIBRATION

Set the voltmeter calibration control H (nearest the meter) and the coarse balance control G (by the power switch) at approximately the middle position of their rotation. Set the hum balancing control F fully counterclockwise. Set the RANGE switch to SET LEVEL position. Set the SENSITIVITY switch to 100%. Set the level control fully counterclockwise.

Plug the line cord into a 105-125 volt 50/60 cycle AC outlet. DO NOT PLUG INTO A DC OUTLET. Like all transformer operated devices, this instrument will not operate on DC and the transformer will be damaged if connected to a DC source.

Turn the power switch on and see if the pilot light and tube heaters light up. The OA2 should show a faint purple glow inside the tube elements after about 30 seconds.

VOLTMETER CALIBRATION

Set the sensitivity switch to 30 volts. Connect a piece of wire between the "hot" input binding post and touch it to one of the pilot light terminals. Try both terminals and use the one that gives an indication on the meter. Set the sensitivity switch to 10 volts. Observe that the meter reading increases. Adjust the voltmeter calibration control to show a 6.3 volt reading on the 0-10 volt scale. NOTE: if a standard meter of known accuracy is available, it may be used to provide a more exact calibration.

BALANCE ADJUSTMENT

Connect the output from an audio generator to the input terminals of the instrument. Set the sensitivity switch to 100%. Set the range switch to one of the SET LEVEL positions. Set the audio generator to 2000 cycles with at least 0.5 volt output. Advance the level control to give a full scale meter reading. Turn the range switch to the 2000-20,000 position. Set the balance control at the middle position of its rotation. (1) Turn the tuning control for a minimum meter indication. (2) Adjust the coarse balance control with a screwdriver for minimum indication. Repeat these two steps until no further improvement is obtained.

NOTE: It may be necessary to turn the sensitivity switch to lower percentage values to show the minimum more clearly.

With the sensitivity switch at 100%, turn the range switch to 200-2000. (1) Turn the tuning control for a minimum meter indication. (2) Adjust the trimmer condenser (through the hole in the top shield) with an insulated screwdriver (alignment tool) for a minimum indication. Repeat these two steps until no further improvement is obtained.

NOTE: It may be necessary to turn the sensitivity switch to lower percentage values to show the minimum more clearly.

Now double check the setting of the coarse balance control by returning to the 2000-20,000 range as before. Finally, recheck the setting of the trimmer condenser by going back to the 200-2000 range again.

HUM BALANCE ADJUSTMENT

Install the instrument in its case with two #6 sheet metal screws through the rear of the cabinet. With no connections made to the input terminal, set the range switch to 20-200, the tuning control to show about 60 on the frequency dial and the sensitivity switch to 1%. Turn the hum balancing control with a screwdriver to give a minimum indication on the meter.

This minimum reading may be expected to fall around 1/10 of full scale and usually depends on the 5879 tube heater to cathode leakage. Readings above 1/10 full scale may drop below that value after a few hours of continuous operation.

This completes the test and calibration. The instrument is ready for use.

IN CASE OF DIFFICULTY

If any difficulty is experienced during test and calibration, proceed as follows:

1. Read the circuit description to understand the principles of operation.
2. Recheck the specific instructions for the test and calibration procedure.
3. Check the operating voltages against the voltage chart. Any large discrepancies may give a clue to the source of the difficulty and further investigation in the particular part of the circuit, both visually and with a voltmeter, may reveal improper construction or faulty components.
4. Frequently much time may be saved by having a friend check the wiring with you. Surprisingly often a simple mistake becomes invisible to the constructor but is clearly evident to another, even unskilled, person.

TABLE OF TYPICAL SOCKET VOLTAGES

TUBE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
5879	0	0	1.7	H	H	0	60	33	0
12AX7	125	33	34	H		103	5.5	12.5	H
12BY7	9	2		H		H	96	96	9
12AT7	85	-0.7	0	H		56	-0.6	0	H
OA2	145	0			145		0		
6X4	220 AC		H	H		220 AC	260		

Heater voltage between pins H is 6-7 volts AC.
All DC voltages measured between pin and chassis using a VTVM with 11 megohm input resistance.

CIRCUIT DESCRIPTION

The Heathkit Harmonic Distortion Meter model HD-1 indicates the remains of the signal under test, after the fundamental frequency is eliminated, as a percentage of the signal under test. The "indicated remains" include all frequencies in the audio range including hum, noise and harmonics from the generator, from the equipment under test and from the instrument itself.

Generally the remains are predominantly the harmonics (multiples of the fundamental test frequency) produced by the equipment under test. The hum, noise and distortion in the instrument are generally less than 0.1%.

The circuit may be considered to have three parts: (a) The fundamental-suppression circuit. (b) The voltmeter circuit. (c) The power supply.

FUNDAMENTAL-SUPPRESSION CIRCUIT

This section consists of a triode voltage amplifier (1/2 12AX7) driving a type of phase splitter using a triode connected pentode (12BY7). The phase splitter feeds the Wien Bridge null network to suppress the fundamental test frequency. The signal voltages that do not cancel in the null network are amplified by a pentode voltage amplifier (5879), which is directly coupled to a triode (1/2 12AX7) connected as a cathode follower.

The Wien Bridge requires two signal voltages of opposite phase at a 2:1 voltage ratio to produce a null. The plate and cathode signal voltages of the phase splitter are of opposite phase. The voltages are approximately 2:1 because of the values of the plate load and cathode load resistors.

The frequency determining elements of the Wien Bridge are the resistance-capacity series arm and the resistance-capacity parallel arm. The resistances are equal, as are the capacities. Minor variations within the tolerance of the precision resistors and variations due to mistracking of the two-gang tuning condenser are compensated by the balance control, which varies the 2:1 voltage ratio a small amount.

The natural response of a Wien Bridge null network is too broad for this instrument, for at twice the null frequency (where the second harmonic appears) the response is still considerably attenuated. Through use of negative feedback around the bridge, from the 1/2 12AX7 cathode follower to the input 1/2 12AX7 cathode, the bridge response is altered to a sharp notch at the null frequency with nearly flat response above twice the null frequency and below half the null frequency.

The range switch selects the resistance values in the Wien Bridge frequency determining arms. The two intermediate switch positions open one arm and short out the other arm. This permits the 12BY7 tube to function as a cathode follower only and drive the 5879 grid directly. Then this section acts as a normal amplifier having the same gain and frequency response but without the Wien Bridge null in the response characteristic.

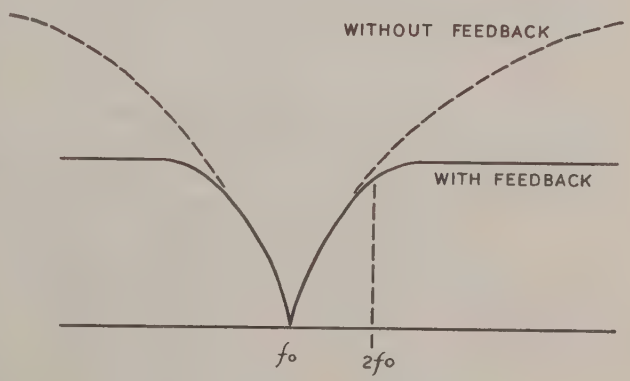
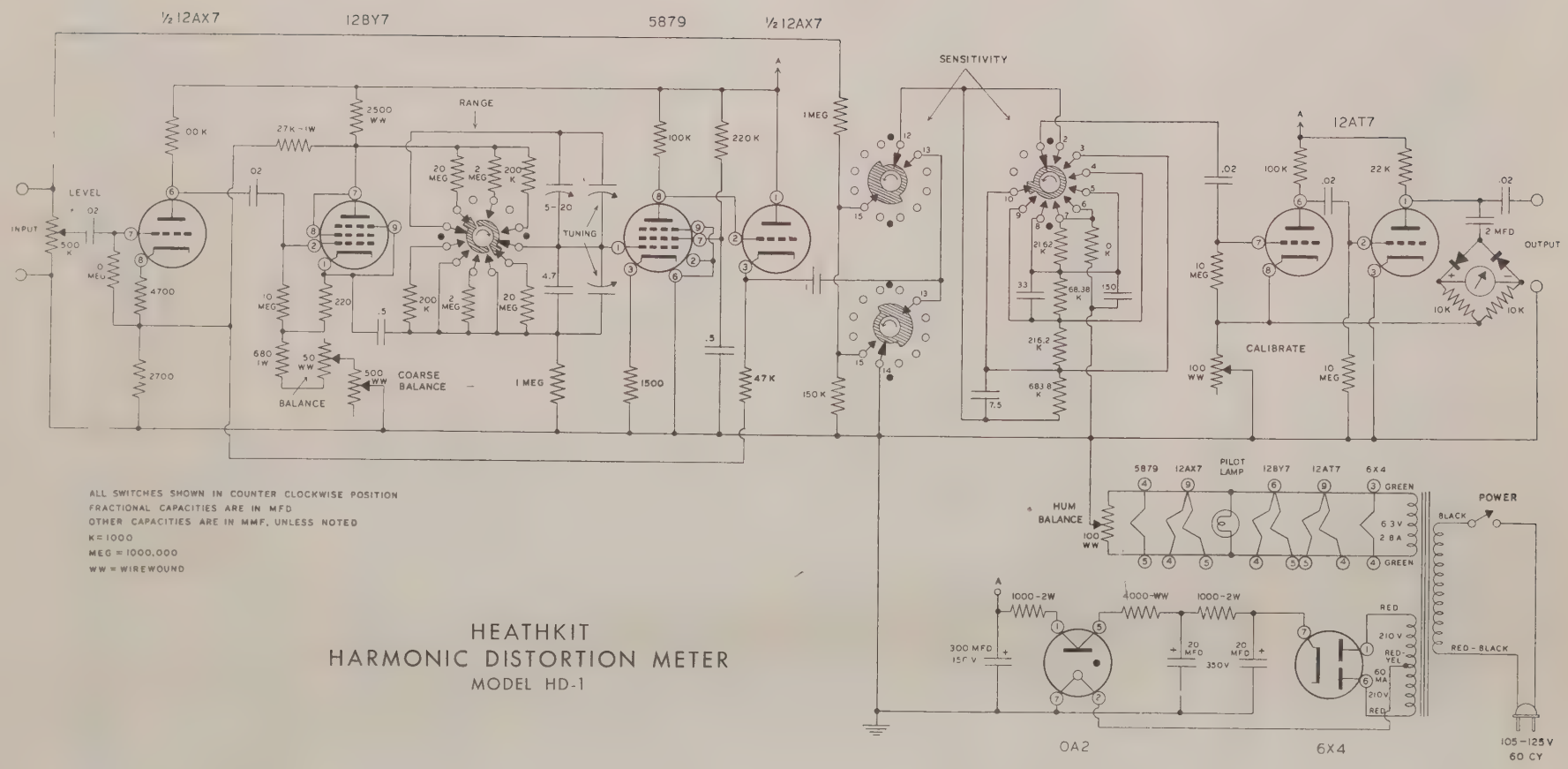


Figure 16

In operation, the WHOLE input signal is fed thru this section to the voltmeter circuit. The operating level of this section is adjusted with the input level control to give a full scale reading on the meter.

Then the Wien Bridge is switched into the circuit and adjusted for elimination of the fundamental and the remaining voltage is read on the meter as distortion in percentage of full scale.



HEATHKIT
HARMONIC DISTORTION METER
MODEL HD-1

The physical construction of the Wien Bridge, such as the "hot" tuning condenser frame and the high impedance above chassis ground level (20 megohms on the 20-200 cycle range), tend to make the instrument subject to hum pickup. This inherent sensitivity is substantially reduced by the feedback loop around the bridge. But during operation at or near line frequency, the null network opens the feedback loop and the hum reduction is thus ineffective. Therefore, shielding the tuning condenser, shielding the range switch, insulating the condenser shaft, balanced filament wiring and a wired ground circuit are used to reduce the residual hum level in the instrument.

VOLTMETER CIRCUIT

This section consists of a two-stage amplifier, using a 12AT7 twin triode, driving a crystal diode half-bridge. Good linearity and frequency response are obtained by negative feedback from the half-bridge to the input cathode. The calibration control permits adjustment of the feedback to give the desired sensitivity. The output voltage of this two-stage amplifier is also available at the output terminals, so the wave shapes of the voltages read on the meter may be visually monitored with an oscilloscope.

The input to the voltmeter is determined by the sensitivity switch which selects the fraction of the voltage desired as well as the source. Full counterclockwise rotation connects the voltmeter to the input binding posts for observation of the signal level. Clockwise rotation reduces the meter reading in steps of 10 db.

In the fifth position, the voltmeter is connected to the cathode follower output of the Fundamental Suppression circuit. Clockwise rotation increases the meter reading in steps of 10 db. The frequency response at the various positions of the sensitivity switch are compensated with fixed condensers. At low sensitivity positions, such compensation is not required.

POWER SUPPLY

The power supply is transformer operated. It provides the filament current for all the tube heaters and the pilot light, as well as highly filtered, voltage regulated plate supply voltage for the instrument. A 6X4 rectifier and an OA2 regulator are used.

APPLICATION

This instrument is used primarily in conjunction with audio frequency sine wave generators to determine the distortion characteristics of audio amplifiers and components used in audio amplifiers.

The distortion of a particular device under test generally varies with output level. Often other factors, such as test frequency, gain control setting and loading of the output may seriously affect the distortion readings obtained.

While frequently a single distortion figure is quoted for a specific test frequency, at a rated output level with a standard dummy load, operating at nominal line voltage, this rarely gives an adequate picture to the design or test engineer, who is concerned with the capabilities under less favorable but realistic conditions. Thus not only a single distortion figure but families of distortion curves are desirable for proper evaluation of equipment under test.

The versatility of the Heathkit Harmonic Distortion Meter makes it possible to obtain adequate data for such curves conveniently and rapidly.

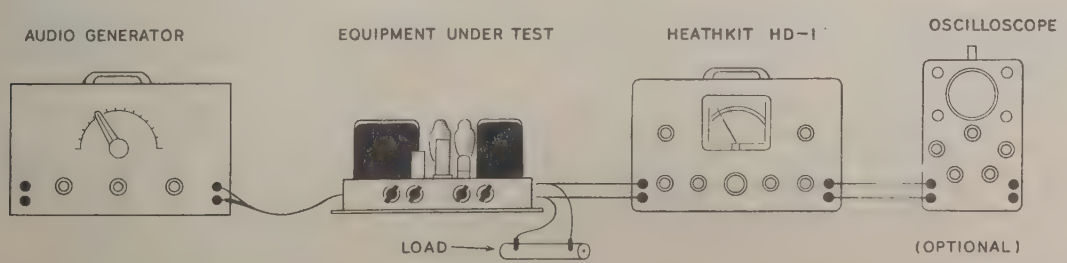
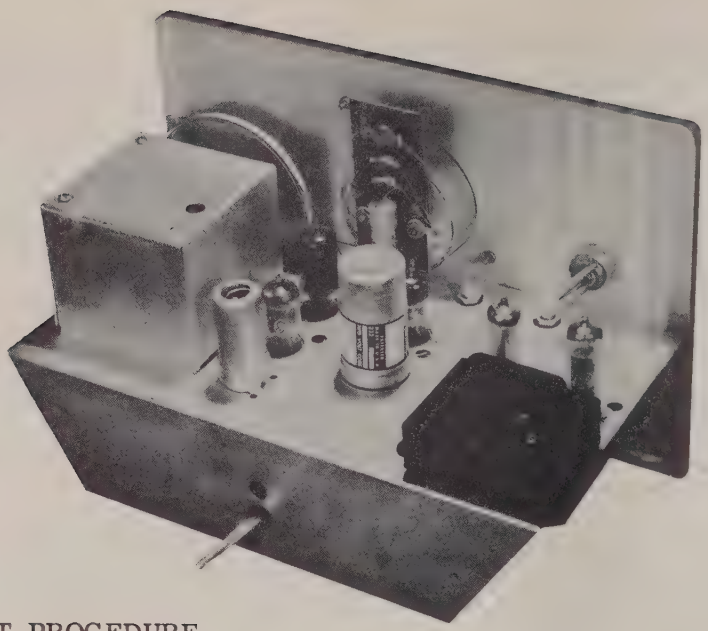


Figure 17



EXAMPLE OF TEST PROCEDURE

Connect an audio generator with sine wave output to the input of the equipment under test. Connect the Harmonic Distortion Meter across the output load of this equipment. Set the range switch to a SET LEVEL position. Set the sensitivity switch to 100%. Adjust the level control for full scale indication on the 0-10 scale.

Reset the range switch to the range appropriate for the generator frequency. Adjust the tuning control for a minimum reading. Adjust the balance control for a minimum reading. Reset the sensitivity switch clockwise to provide a more readable indication. Readjust tuning and balance controls for a minimum reading. Read the total harmonic distortion on the meter and sensitivity switch.

Rotate the sensitivity switch counterclockwise to a voltage position that gives a suitable meter reading to note the input level to the distortion meter. This voltage reading may be used to calculate the output power level of the equipment under test or the reading on the db scale may be used for comparative purposes.

While the majority of measurements will be made on complete amplifiers, often effective use may be made of this instrument to check portions of amplifiers during the development. The effect of changed operating voltages or circuit constants is readily observed and thus optimum operating conditions may be established. This instrument lends itself also to other applications such as measuring the distortion in receivers and transmission lines. With a high quality microphone and amplifier connected to the instrument, the distortion introduced by a speaker may be determined.

With the range switch in the SET LEVEL position, the bridge amplifier may be used as a preamplifier for the voltmeter. The level control may be used to select a usable sensitivity. A simple way to set the level control for a convenient high value of sensitivity is as follows:

Connect a generator to the input of the instrument. Using the 1 volt scale, adjust the generator output to 0.3 volts. Switch to 100% and adjust level control for full scale. The instrument will now read:

0.3 volts full scale on 100% setting
0.1 volts full scale on 30% setting
0.03 volts full scale on 10% setting
0.01 volts full scale on 3% setting
0.003 volts full scale on 1% setting

If the signal source is 600 ohms, the 0 db marks corresponds to:

-10 dbm at 100%
-20 dbm at 30%
-30 dbm at 10%
-40 dbm at 3%
-50 dbm at 1%

The -10 db mark at the 1% scale corresponds to -60 dbm.

Noise levels are frequently expressed as a number of db below a certain output level. Thus an amplifier with a nominal output of 5.4 volts would read -3 db on the red scale, using the 10 volt position. Turning off the generator, the output level would drop. Assuming the level control on the instrument was adjusted as previously described, turning sensitivity switch to 100% makes the range 30 db less.

If a usable reading is found on the 3% scale of +1 db for instance, the noise level is then -3 -60 + 1 = 62 db. In this measurement, noise level is purely a ratio of signal voltage to noise voltage and is expressed as db, not dbm, and a statement of reference level is generally desirable:

noise level 62 db below 3.6 watts (5.4 volts across 8 ohms).

ACCURACY

VOLTMETER: The full scale accuracy of the voltmeter depends primarily on the exactness of the voltage divider resistors, which are within 1%, and the accuracy of calibration. The accuracy of meter indications of less than full scale is affected by linearity of the crystal diode bridge, the amplifiers and the meter. The overall accuracy should fall well within 5% of FULL SCALE.

DISTORTION: The accuracy of the distortion measurement depends primarily on the completeness of the null and the residual noise, distortion and hum generated within the instrument. The overall accuracy should fall well within 5% of FULL SCALE + 0.1% distortion.

The accuracy of the distortion measurement is independent of the accuracy of the calibration of the voltmeter, because the same meter sensitivity is used in the SET LEVEL position.

BIBLIOGRAPHY

Additional information on the subject of harmonic distortion and its measurement may be found in various textbooks and magazine articles. Some of these sources are listed below.

Terman and Pettit; Electronic Measurements; 2nd Edition, McGraw-Hill, 1952
Turner; Basic Electronic Test Instruments; Rinehart Books, 1952
Valley and Wallman; Vacuum Tube Amplifiers; McGraw-Hill, 1948
Langford Smith; Radiotron Designers Handbook, 4th Edition, RCA, 1952
Jones; Theory and Construction of a Harmonic Distortion Meter, Audio Engineering, Nov. 1952

Other articles pertaining to the subject:

Radio Electronics, August 1954, p. 39
Electronics, February 1953, p. 212
Radio Electronics, August 1952, p. 42
Audio Engineering, April 1951, p. 18
Audio Engineering, December 1951, p. 2
Radio Electronics, December 1951, p. 34
Radio and Television News, March 1951, p. 46
Audio Engineering, November 1950, p. 22
Radio Electronics, April 1949, p. 60
Radio and Television News, November 1949, p. 44
Radio and Television News, November 1948, p. 68

REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
B. Identify the type and model number of kit in which it is used.
C. Mention the order number and date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SERVICE

In event continued operational difficulties of the completed instrument are experienced, the facilities of the Heath Company Service Department are at your disposal. Your instrument may be returned for inspection and repair for a service charge of $5.00 plus the cost of any additional material that may be required. THIS SERVICE POLICY APPLIES ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned not repaired.

The Heath Company is willing to offer its full cooperation to assist you in obtaining the specified performance level in your instrument. Factory repair service is available for a period of one year from the date of purchase or you may contact the Engineering Consultation Department by mail. For information regarding possible modification of existing kits, it is suggested that you refer to any one or more of the many publications that are available on all phases of electronics. They can be obtained at or through your local library, as well as at any electronic outlet store. Although the Heath Company sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for specific purposes. Therefore, such modifications must be made at the discretion of the kit builder according to information which will be much more readily available from some local source.

SHIPPING INSTRUCTIONS

Before returning a unit for service, be sure that all parts are securely mounted. Attach a tag to the instrument giving name, address and trouble experienced. Pack in a rugged container, preferably wood, using at least three inches of shredded newspaper or excelsior on all sides. DO NOT SHIP IN THE ORIGINAL KIT CARTON AS THIS CARTON IS NOT CONSIDERED ADEQUATE FOR SAFE SHIPMENT OF THE COMPLETED INSTRUMENT. Ship by prepaid express if possible. Return shipment will be made by express collect. Note that a carrier connot be held liable for damage in transit if packing, in HIS OPINION, is insufficient.

SPECIFICATIONS

All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

WARRANTY

The Heath Company limits its warranty of parts supplied with any kit to a period of three (3) months from the date of purchase. Replacement will be made only when said part is returned postpaid, with prior permission and in the judgment of the Heath Company was defective at the time of sale. This warranty does not extend to any Heathkits which have been subjected to misuse, neglect, accident and improper installation or applications. Material supplied with a kit shall not be considered as defective, even though not in exact accordance with specifications, if it substantially fulfills performance requirements. This warranty is not transferable and applies only to the original purchaser. This warranty is in lieu of all other warranties and the Heath Company neither assumes nor authorizes any other person to assume for them any other liability in connection with the sale of Heathkits.

The assembler is urged to follow the instructions exactly as provided. The Heath Company assumes no responsibility or liability for any damages or injuries sustained in the assembly of the device or in the operation of the completed instrument.

HEATH COMPANY
Benton Harbor, Michigan

PARTS LIST

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-45	1	220 Ω
1-11	1	1500 Ω
1-13	1	2700 Ω
1-16	1	4700 Ω
1-20	2	10 KΩ
1-22	1	22 KΩ
1-25	1	47 KΩ
1-26	3	100 KΩ
1-27	1	150 KΩ
1-29	1	220 KΩ
1-35	2	1 megohm
1-40	4	10 megohm
1-21A	1	680 Ω 1 watt
1-46A	1	27 KΩ 1 watt
1-15B	2	1000 Ω 2 watt
2-50	1	10 KΩ precision
2-39	1	21.62 KΩ precision
2-40	1	68.38 KΩ precision
2-42	1	216.2 KΩ precision
2-45	1	683.8 KΩ precision
2-54	2	200 KΩ precision
2-55	2	2 megohm precision
2-26A	2	20 megohm precision
3-1E	1	2500 Ω 5 watt
3-8G	1	4000 Ω 7 watt

PART No.	PARTS Per Kit	DESCRIPTION
Condensers		
21-29	1	4.7 μμf ceramic tubular
20-52	1	7.5 μμf mica
21-7	1	33 μμf ceramic disc
21-11	1	150 μμf ceramic disc
21-31	5	.02 μfd ceramic disc
23-28	1	.1 μfd paper tubular
23-56	2	.5 μfd paper tubular
23-17	1	2 μfd metalite
25-30	1	20-20 μfd 350 v. electrolytic
25-38	1	300 μfd 150 v. electrolytic
26-9	1	Dual 420 μμf tuning
31-6	1	5-20 μμf trimmer
Controls-Switches		
10-16	1	500 KΩ audio control
11-17	2	100 Ω wirewound control
11-21	1	50 Ω wirewound control
11-22	1	500 Ω wirewound control
63-100	1	5-position switch RANGE
63-101	1	9-position switch SENSITIVITY
63-102	1	On-off switch

PART No.	PARTS Per Kit	DESCRIPTION
Binding Post Parts		
75-17	8	Insulator bushing
100-M16B	2	Black cap
100-M16R	2	Red cap
427-2	4	Base
Transformer-Diodes-Meter		
54-5	1	Power transformer
56-1	2	Crystal diode
407-8A	1	200 microammeter
Dial Drive Parts		
100-M62	1	Drive pulley
100-M64	1	Dial cord
258-4	1	Dial cord spring
453-12	1	Extension shaft
453-13	1	Drive shaft
455-6	3	Shaft bushing
456-4	1	Insulated coupling
Grommets-Insulator-Feet		
73-1	3	3/8" grommet
73-3	1	1/2" grommet
75-5	1	Tuning condenser insulator
261-1	4	Rubber feet
Metal Parts		
90-24	1	Cabinet
200-M85	1	Chassis
203-73F99	1	Panel
204-M88	1	Drive bracket
204-M89	1	Control bracket
206-3	1	Tube shield
206-M35	1	Upper front shield
206-M36	1	Lower front shield
206-M37	2	Rear shield
206-M38	1	Top shield
206-M39	1	Bottom shield
211-1	1	Handle
Wire-Sleeving		
89-1	1	Line cord
340-2	1	length Bare wire
343-3	1	length Spiral shielded wire
344-1	1	length Hookup wire
346-1	1	length Sleeving, thin
346-2	1	length Sleeving, large
346-6	1	length Sleeving, 3/8"

PART No.	PARTS Per Kit	DESCRIPTION
Tubes-Lamp		
411-24	1	12AT7 tube
411-26	1	12AX7 tube
411-59	1	OA2 tube
411-64	1	6X4 tube
411-69	1	12BY7 tube
411-78	1	5879 tube
412-1	1	#47 pilot lamp
Terminal Strips		
431-15	4	1-lug terminal strip
431-2	1	2-lug terminal strip
431-10	1	2-lug + 1 grounded lug strip
431-3	1	3-lug terminal strip
431-22	1	Meter terminal board
Sockets		
434-15	2	7-pin wafer socket
434-16	3	9-pin wafer socket
434-43	1	9-pin shielded socket
434-21	1	Pilot lamp socket
Knobs		
462-19	5	Skirted index knob
462-37	1	Indicator knob
462-26	1	Large tuning knob
Hardware		
250-2	12	3-48 screw
250-8	10	#6 sheet metal screw
250-31	3	6-32 x 1/4 screw
250-9	13	6-32 x 3/8 screw
250-15	2	8-32 x 1/8 set screw
250-16	2	8-32 x 3/16 set screw
250-43	6	8-32 x 1/4 set screw
250-19	2	10-24 x 3/8 screw
252-1	12	3-48 nut
252-3	17	6-32 nut
252-4	2	8-32 nut
252-7	11	Control nut
253-10	7	Control nickel washer
253-11	2	"E" washer
253-15	3	Fiber flat control washer
253-16	3	Fiber shoulder control washer
254-1	15	#6 lockwasher
254-2	2	#8 lockwasher
254-4	11	Control lockwasher
259-1	5	#6 solder lug
481-1	1	Condenser mounting wafer

HELPFUL KIT BUILDING INFORMATION

Before attempting actual kit construction read the construction manual through thoroughly to familiarize yourself with the general procedure. Note the relative location of pictorials and pictorial inserts in respect to the progress of the assembly procedure outlined.

This information is offered primarily for the convenience of novice kit builders and will be of definite assistance to those lacking thorough knowledge of good construction practices. Even the advanced electronics enthusiast may benefit by a brief review of this material before proceeding with kit construction. In the majority of cases, failure to observe basic instruction fundamentals is responsible for inability to obtain desired level of performance.

RECOMMENDED TOOLS

The successful construction of Heathkits does not require the use of specialized equipment and only basic tools are required. A good quality electric soldering iron is essential. The preferred size would be a 100 watt iron with a small tip. The use of long nose pliers and diagonal or side cutting pliers is recommended. A small screw driver will prove adequate and several additional assorted screw drivers will be helpful. Be sure to obtain a good supply of rosin core type radio solder. Never use separate fluxes, paste or acid solder in electronic work.

ASSEMBLY

In the actual mechanical assembly of components to the chassis and panel, it is important that the procedure shown in the manual be carefully followed. Make sure that tube sockets are properly mounted in respect to keyway or pin numbering location. The same applies to transformer mountings so that the correct transformer color coded wires will be available at the proper chassis opening.

Make it a standard practice to use lock washers under all 6-32 and 8-32 nuts. The only exception being in the use of solder lugs—the necessary locking feature is already incorporated in the design of the solder lugs. A control lock washer should always be used between the control and the chassis to prevent undesirable rotation in the panel. To improve instrument appearance and to prevent possible panel marring use a control flat nickel washer under each control nut.

When installing binding posts that require the use of fiber insulating washers, it is good practice to slip the shoulder washer over the binding post mounting stud before installing the mounting stud in the panel hole provided. Next, install a flat fiber washer and a solder lug under the mounting nut. Be sure that the shoulder washer is properly centered in the panel to prevent possible shorting of the binding post.

WIRING

When following wiring procedure make the leads as short and direct as possible. In filament wiring requiring the use of a twisted pair of wires allow sufficient slack in the wiring that will permit the twisted pair to be pushed against the chassis as closely as possible thereby affording relative isolation from adjacent parts and wiring.

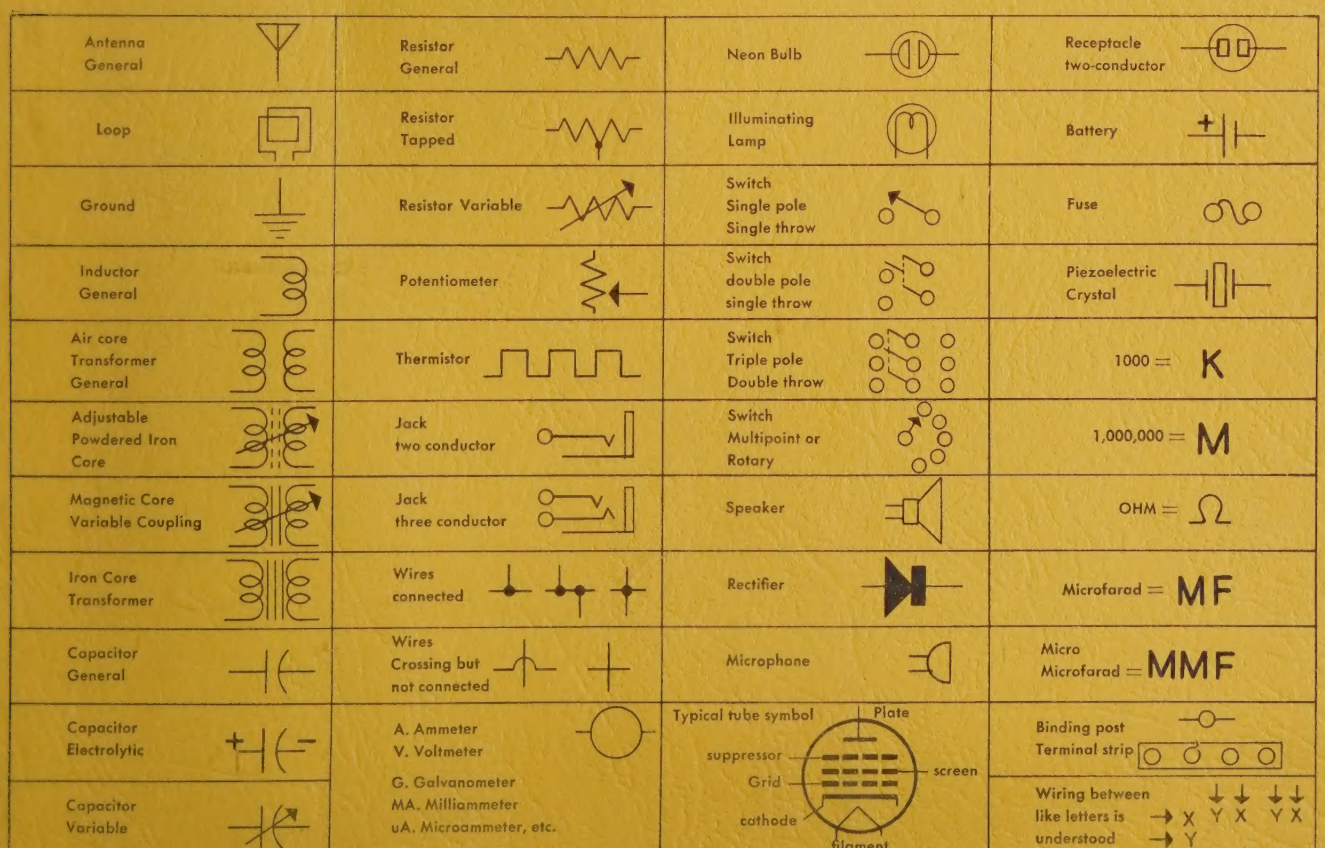
When removing insulation from the end of hookup wire, it is seldom necessary to expose more than a quarter inch of the wire. Excessive insulation removal may cause a short circuit condition in respect to nearby wiring or terminals. In some instances, transformer leads of solid copper will have a brown baked enamel coating. After the transformer leads have been trimmed to a suitable length, it is necessary to scrape the enamel coating in order to expose the bright copper wire before making a terminal or soldered connection.

In mounting parts such as resistors or condensers, trim off all excess lead lengths so that the parts may be installed in a direct point-to-point manner. When necessary use spaghetti or insulated sleeving over exposed wires that might short to nearby wiring.

It is urgently recommended that the wiring dress and parts layout as shown in the construction manual be faithfully followed. In every instance, the desirability of this arrangement was carefully determined through the construction of a series of laboratory models.

SOLDERING

Much of the performance of the kit instrument, particularly in respect to accuracy and stability, depends upon the degree of workmanship used in making soldered connections. Proper soldered connections are not at all difficult to make but it would be advisable to observe a few precautions. First of all before a connection is to be soldered, the connection itself should be clean and mechanically strong. Do not depend on solder alone to hold a connection together. The tip of the soldering iron should be bright, clean and free of excess solder. Use enough heat to thoroughly flow the solder smoothly into the joint. Avoid excessive use of solder and do not allow a flux flooding condition to occur which could conceivably cause a leakage path between adjacent terminals on switch assemblies and tube sockets. This is particularly important in instruments such as the VTVM, oscilloscope and generator kits. Excessive heat will also burn or damage the insulating material used in the manufacture of switch assemblies. Be sure to use only good quality rosin core radio type solder.



Courtesy of I. R. E.

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THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM

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